

Short communication

Cat, dog, and house-dust-mite allergen levels of house dust in Finnish apartments

Raunio P, Pasanen A-L, Reiman M, Virtanen T. Cat, dog, and house-dust-mite allergen levels of house dust in Finnish apartments. *Allergy* 1998; 53: 195–199. © Munksgaard 1998.

The presence of indoor allergens in Finnish homes was studied for the first time. Dust samples ($n=30$) were collected by vacuuming a 1 m^2 area from a living-room carpet in 30 apartments divided into three groups: homes with cats ($n=10$), homes with dogs ($n=10$), and homes without pets ($n=10$). The levels of major cat (Fel d 1), dog (Can f 1), and house-dust-mite (Der p 1) allergens were analyzed by two-site ELISA methods. Der p 1 levels were below the detection limit in all dust samples. In the homes with cats or dogs, Fel d 1 and Can f 1 levels ranged from 147 to $2800\text{ }\mu\text{g/g}$ (geometric mean $567\text{ }\mu\text{g/g}$), and from 86 to $1400\text{ }\mu\text{g/g}$ (geometric mean $296\text{ }\mu\text{g/g}$), respectively, being slightly higher than those reported elsewhere. Low allergen levels, mainly below $3\text{ }\mu\text{g/g}$, were also detected in the homes without pets, indicating the transfer of allergens from place to place. However, in 25% of these samples, allergen levels exceeded the proposed threshold levels for cat or dog sensitization. The presence of pets was the most significant factor affecting cat and dog allergen levels in the house dust, and other factors, such as the amount of dust collected, residential time, and cleaning habits, had no or only a weak effect on allergen levels.

**P. Raunio¹, A.-L. Pasanen¹,
M. Reiman², T. Virtanen³**

¹University of Kuopio, Department of Environmental Sciences, Kuopio; ²Kuopio Regional Institute of Occupational Health, Kuopio, ³University of Kuopio, Department of Clinical Microbiology, Kuopio, Finland

Key words: Can f 1; Der p 1; Fel d 1; floor dust; home; indoor allergens.

Dr A.-L. Pasanen
Department of Environmental Sciences
University of Kuopio
PO Box 1627
FIN-70211 Kuopio
Finland

Accepted for publication 22 August 1997

The prevalence of allergen sensitization and asthma in the population has increased rapidly in recent decades, especially among children. The increased frequency of keeping pets indoors, changes in housecleaning habits, and the increased proportion of time spent indoors have increased the exposure to indoor allergens. Furred pets, particularly cats, and house-dust mites are considered to be important sources of indoor allergens and significant causes of allergen sensitization and allergic diseases in the home environment, especially during non-peak pollen seasons (1–4). Two cat allergen (Fel d 1) levels of 2 and $8\text{ }\mu\text{g/g}$ of house dust have been suggested as the threshold values for sensitization (5, 6), and exposure to concentrations of Fel d 1 greater than $10\text{ }\mu\text{g/g}$ could be a risk factor for acute asthma attacks (7). Correspondingly, dog allergen (Can f 1) levels above $10\text{ }\mu\text{g/g}$ have been suggested as the threshold level for sensitization to dog (8). For house-dust-mite allergen (Der p 1 and Der f 1), the sensitizing level would be $2\text{ }\mu\text{g/g}$, and the level for asthma symptoms $10\text{ }\mu\text{g/g}$ (9, 10).

The levels of Fel d 1 and Can f 1 allergen in the house dust of homes and other nonindustrial buildings reported in the literature are presented in Table 1. In general, the levels of cat or dog allergen in the house dust of homes with cats or dogs have been about one or two orders of magnitude higher than in homes and other buildings where the pets are not present. House-dust-mite allergen levels exceeding the proposed threshold values for sensitization and asthma symptoms have been measured in studies from Australia, Japan, The Netherlands, Denmark, and the UK (22–26). On the other hand, in drier and colder climates, as in Sweden and Canada, mite allergen levels lower than $2\text{ }\mu\text{g/g}$ have usually been found (15, 20, 27).

Indoor allergen levels in Finnish homes may be assumed to be the same as those reported in Swedish studies because the way of life, housing style, building characteristics, and climate are quite similar in Sweden and Finland. However, no information on indoor allergen levels of house dust in Finnish buildings has been reported so far. This

Table 1. Cat (Fel d 1) and dog (Can f 1) allergen levels in floor/carpet dust collected in buildings with and without pets in some studies

Allergen	Type of building	Allergen level in dust ($\mu\text{g/g}$); range (mean ^b)				Country	Reference
		<i>n</i> ^a	Cats/dogs in building	<i>n</i>	No cat/dog in building		
Fel d 1	Homes	12	28–1412 (246)	10	<0.08–16 (1.5)	USA	11
	Homes, stores, hospitals, offices	— ^c	6	30	0.01–5.2	USA	12, 13
	31 homes	20	0.4–3328 (186)	11	<0.004–41 (0.95)	USA	14
	39 homes	—	0.3–2.2 (0.78)	—	0.07–1.0 (0.2–0.4)	Sweden	15
	29 classrooms	—	—	—	0.02–0.57 (0.13)	Sweden	16
	13 homes	6	92–948 (322)	5	0.8–1.6 (1.2)	Japan	17
	40 homes	—	—	40	<0.05–3.8 (0.26)	USA	18
	60 day nurseries	—	—	76	<0.1–2.4 (0.8)	France	19
	109 homes	44	1–1000	—	0.5–1000	USA	8
	120 homes	18	0.3–26.3 (6.16)	102	0.07–13.7 (0.63–1.25)	Canada	3
	40 schools	—	—	98	<0.02–0.4 (0.13)	Sweden	20
	103 homes	56	10–10 000 (120)	43	<0.3–23 (3)	USA	21
	29 classrooms	—	—	29	0.06–0.5 (0.2)	Sweden	16
	13 homes	3	80–420 (236)	5	<0.8–1.3	Japan	17
Can f 1	60 day nurseries	—	—	46	<0.2–1.2	France	19
	40 schools	—	—	98	<0.02–4.0 (0.64)	Sweden	20

^a *n*: number of dust samples; ^b mean: arithmetic or geometric mean; ^c—: data not available.

study was performed to determine Fel d 1, Can f 1, and Der p 1 allergen levels in house dust collected from 30 Finnish homes.

Material and methods

Sampling of house dust

Thirty apartments in apartment buildings ($n=30$) in Kuopio, a town in central Finland, were selected for sampling sites. Residents in 10 homes had one to three cats, those in 10 other homes had one or two dogs, and no pets were kept in the remaining 10 homes. The residents reported no indoor air quality problems or acute moisture damage in the homes. Each home was visited once, and all dust samples were collected within 3 weeks in October and November 1996. During the sampling, the room temperature of the homes (living rooms) ranged from 19 to 23°C, and the relative humidity (RH) from 27 to 53%. In a questionnaire, the residents reported current or past keeping of pets, visits to other people who had pets, and housecleaning habits.

House-dust samples ($n=30$) were collected on cellulose acetate/cellulose nitrate filters (Millipore AAWP09000, pore size 0.8 μm) by vacuuming a 1 m² area from living-room carpets for 2 min with a vacuum cleaner (Miele s251i) with a Cutler-type nozzle. Dust samples were weighed and stored in glass Petri dishes at –20°C until extraction. The mass of dust samples collected ranged from 0.08 to 2.07 g per sample.

Extraction of dust and allergen assays

Dust samples were extracted in phosphate-buffered saline (pH 7.4) containing 0.05% (v/v) Tween-20 (PBS-Tween) in an average volume of 57.5 ml/g of dust (range 9.6–158.3 ml/g) in a shaker (150 rpm) for 2 h at room temperature. The wide range of the extraction volume was due to variation in quality and content of dust samples. Extracts were centrifuged (34 500 g, 45 min), and supernatants were stored at –20°C until ELISA analysis.

The levels of major cat (Fel d 1), dog (Can f 1), and house-dust-mite (Der p 1) allergens were analyzed by two-site ELISA methods, according to the reagent supplier's instructions, as described by Luczynska et al. (28), adapting the principles of ELISA techniques reported previously from our laboratory (29). All allergen-specific reagents and standards were purchased from Indoor Biotechnologies Ltd, UK. Plates were coated with mAbs against Fel d 1 (6F9), Can f 1 (6E9), or Der p 1 (5H8) at the concentration of 10 $\mu\text{g/ml}$. Allergen standards were used at twofold dilutions at the concentration ranges of 1.5–12 ng/ml (Fel d 1), 3.9–62.4 ng/ml (Can f 1), or 0.12–7.68 ng/ml (Der p 1). For dust samples, appropriate dilutions were chosen. Bound material was detected by either biotinylated mAbs (3E4 against Fel d 1 or 4C1 against Der p 1) or allergen-specific antiserum (Can f 1). The mAb 3E4 was then detected by Vectastain Elite ABC reagents (Vector Laboratories, Inc., USA) and the antiserum with peroxidase-conjugated goat antirabbit IgG (Zymed Laboratories,

Inc., USA). The mAb 4C1 was detected by the 1/6000-diluted polymer amplifier (Amdex, Amersham Life Science, UK).

Color reactions were developed and measured as reported before (29). The results were calculated from the straight part of the standard curves, and the allergen levels were expressed as the mean of duplicate measurements (μg of Fel d 1, Can f 1, or Der p 1 per gram of original dust).

Results

Fel d 1 and Can f 1 levels in house dust collected from 30 homes are presented in Table 2. Der p 1 levels remained below the detection limit (about 14 ng/g) in all dust samples even though a special amplifier which achieves about a 15 times lower detection limit than the Vectastein Elite ABC avidin-biotin system (data not shown) was used. As expected, Fel d 1 and Can f 1 levels were 10–1000 times higher in the homes with cats or dogs, respectively, than in those without pets. The differences were statistically significant ($P < 0.001$). In addition, low allergen levels, mainly $< 3 \mu\text{g/g}$, were also measured in the homes without pets. No difference in Fel d 1 levels was observed between the homes with dogs and those without pets, just as there was no difference in Can f 1 levels between the homes with cats and those without pets. A wide variation in the allergen levels in each home group was caused by high allergen levels in a few dust samples.

Over the whole data, the allergen levels of dust did not correlate with the mass of dust collected, the frequency of vacuuming, the last vacuuming preceding the sampling, and the floor area of the homes. In the homes without pets, a slight correlation was found between the level of Fel d 1 and the mass of dust collected (Spearman's rank correlation test: $r = 0.63$, $P = 0.049$). No such correlation was observed in the homes with cats. On the other

hand, in the homes with cats, Fel d 1 levels were higher the longer the residents had lived there ($r = 0.66$, $P = 0.04$). Surprisingly, the frequency of housecleaning correlated positively with the Can f 1 level of dust ($r = 0.65$, $P = 0.04$) in the homes with dogs.

Discussion

Low levels of house-dust-mite allergens in house dust ($< 2 \mu\text{g/g}$) have usually been found in buildings situated in regions with a cold and dry climate (15, 20, 27). In this study, Der p 1 levels were below the detection limit (about 14 ng/g) in all dust samples. This was probably due to the relatively low RH of indoor air (RH 27–53%) in the homes. Our results do not, however, exclude the possibility that there were mite allergens in the other areas more suitable for mites, such as mattresses.

In this study, the Fel d 1 levels of house dust in most samples were in the range of 150–540 $\mu\text{g/g}$ in the homes with cats, and those of Can f 1 were in the range of 140–570 $\mu\text{g/g}$ in the homes with dogs. These concentrations exceed the proposed threshold values for cat and dog sensitization and acute asthma symptoms (5–8) by one or two orders of magnitude. The levels were slightly higher than those reported in the literature (Table 1). This may result from differences between countries in factors such as housing and cleaning habits, the practice of keeping pets indoors, or the methods of allergen measurement.

Measurable Fel d 1 and Can f 1 allergen levels in house dust were also detected in the homes without cats or dogs. The levels were approximately in the same range as those published elsewhere (Table 1). The levels of Fel d 1 exceeded the proposed threshold value for cat sensitization (2 $\mu\text{g/g}$) (7) in four homes without cats. Can f 1 levels exceeded the proposed sensitizing level of 10 $\mu\text{g/g}$ (8) in only one home without pets. It may

Table 2. Fel d 1 and Can f 1 allergen levels in house dust collected by vacuuming living-room carpets in homes with cats or dogs or without pets

Allergen	Allergen level ($\mu\text{g/g}$ of dust)		
	Homes with cats	Homes with dogs	Homes without pets
Fel d 1			
Arithmetic mean $\pm$ SD ^d	860 $\pm$ 867	0.5 $\pm$ 0.7	1.2 $\pm$ 1.3
Geometric mean	567	0.3	0.5
Range	147–2800	0.1–2.6	< 0.09 –3.3
Can f 1			
Arithmetic mean $\pm$ SD	2.4 $\pm$ 2.0	400 $\pm$ 381	3.0 $\pm$ 4.3
Geometric mean	1.8	296	3.0
Range	0.6–7.4	87–1400	0.4–14

^d SD: standard deviation.

be assumed that the allergens observed in the homes without pets were probably transferred in visitors' or residents' clothes. Another possibility is that the former residents in the home had had pets (3, 12, 15, 16).

The data of the present study showed that the presence of cats or dogs in a home is the most significant cause of increased *Fel d 1* and *Can f 1* levels in the house dust, and that other factors, such as the mass of dust collected and the frequency of cleaning (vacuuming), have no or only a weak effect on allergen levels. The same phenomenon has also been observed with house-dust-mite allergens in another study (30). However, a slight positive correlation was observed between the *Fel d 1* levels of dust and the residential time in the homes with cats in this study. This supports the idea that cat allergens as stable proteins accumulate in the cracks of floors and walls, in textiles, and in upholstered furniture (11, 14).

References

1. Platts-Mills TAE. How environment affects patients with allergic disease: indoor allergens and asthma. *Ann Allergy* 1994;72:381-4.
2. Lin RY, LaFrance J, Sauter D. Hypersensitivity to common indoor aeroallergens in asthmatic patients. *Ann Allergy* 1993;71:33-9.
3. Quirce S, Dimich-Ward H, Chan H, et al. Major cat allergen (*Fel d 1*) levels in the homes of patients with asthma and their relationship to sensitization to cat dander. *Ann Allergy Asthma Immunol* 1995;75:325-30.
4. Silvestri M, Oddera S, Rossi GA, Crimi P. Sensitization to airborne allergens in children with respiratory symptoms. *Ann Allergy Asthma Immunol* 1996;76:239-44.
5. Call RS, Smith TF, Morris E, Chapman M, Platts-Mills TAE. Risk factors for asthma in inner city children. *J Pediatr* 1992;121:862-6.
6. Gelber LE, Seltzer LH, Bouzoukis JK, Pollart SM, Chapman D, Platts-Mills TAE. Sensitization and exposure to indoor allergens as risk factors for asthma among patients presenting to hospital. *Am Rev Respir Dis* 1993;147:573-8.
7. Pollart SM, Chapman MD, Fiocco GP, Rose G, Platts-Mills TAE. Epidemiology of acute asthma: IgE antibodies to common inhalant allergens as a risk factor for emergency room visits. *J Allergy Clin Immunol* 1989;83:875-82.
8. Ingram JM, Sporik R, Rose GR, Honsinger R, Chapman MD, Platts-Mills TAE. Quantitative assessment of exposure to dog (*Can f 1*) and cat (*Fel d 1*) allergens: relationship to sensitization and asthma among children living in Los Alamos, New Mexico. *J Allergy Clin Immunol* 1995;96:449-56.
9. Platts-Mills TAE, de Weck AL. Dust mite allergens and asthma: a worldwide problem. International workshop report. *J Allergy Clin Immunol* 1989;83:416-27.
10. Platts-Mills TAE, Thomas WR, Aalberse RC, Vervloet D, Chapman MD. Dust mite allergens and asthma: report of a second international workshop. *J Allergy Clin Immunol* 1992;89:1046-60.
11. Wood R, Chapman M, Adkinson N, Eggleston PA. The effect of cat removal on allergen content in household dust samples. *J Allergy Clin Immunol* 1989;83:730-4.
12. Enberg R, Shamie S, McCullough J, Ownby D. Ubiquitous presence of cat allergen in cat-free buildings: probable dispersal from human clothing. *Ann Allergy* 1993;70:471-4.
13. Shamie S, Enberg R, Terry L, Ownby D. The consistent presence of cat allergen (*Fel d 1*) in various types of public places [Abstract]. *J Allergy Clin Immunol* 1990;85:226.
14. Wood R, Mudd K, Eggleston P. The distribution of cat and dust mite allergens on wall surfaces. *J Allergy Clin Immunol* 1992;89:126-30.
15. Munir AKM, Einarsson R, Kjellman N-IM, Björkstén B. Mite (*Der p 1*, *Der f 1*) and cat (*Fel d 1*) allergens in the homes of babies with a family history of allergy. *Allergy* 1993;48:158-63.
16. Munir A, Einarsson R, Shou C, Dreborg S. Allergens in school dust. I. The amount of the major cat allergen (*Fel d 1*) and dog (*Can f 1*) allergens in dust from Swedish schools is high enough to probably cause perennial symptoms in most children with asthma who are sensitized to cat and dog. *J Allergy Clin Immunol* 1993;91:1067-74.
17. Sakaguchi M, Inouye S, Irie T, et al. Airborne cat (*Fel d 1*), dog (*Can f 1*) and mite (*Der I* and *Der II*) allergen levels in the homes of Japan. *J Allergy Clin Immunol* 1993;92:797-802.
18. Bollinger M, Eggleston P, Flanagan E, Wood R. Clinical aspects of allergic disease: cat antigen in homes with and without cats may induce allergic symptoms. *J Allergy Clin Immunol* 1996;97:907-14.
19. de Andrade AD, Charpin D, Birnbaum J, Lanteaume A, Chapman M, Vervloet D. Indoor allergen levels in day nurseries. *J Allergy Clin Immunol* 1995;95:1158-63.
20. Norbäck D, Smedje G. Aerosols, subjective indoor air quality and asthma in schools. *Ann Occup Hyg* 1997;41 (in press).
21. Schou C, Hansen G, Lintner T, Løwenstein H. Assay for the major dog allergen, *Can f 1*: investigation of house dust samples and commercial dog extracts. *J Allergy Clin Immunol* 1991;88:847-53.
22. Custovic A, Taggart S, Francis H, Chapman M, Woolcock A. Exposure to house dust mite allergens and the clinical activity of asthma. *J Allergy Clin Immunol* 1996;98:64-72.
23. Lau S, Falkenhurst G, Weber A, et al. High mite allergen exposure increases the risk of sensitization in atopic children and young adults. *J Allergy Clin Immunol* 1989;84:718-25.
24. Marks G, Tovey E, Toelle B, Wachinger S, Peat J, Woolcock A. Mite allergen (*Der p 1*) concentration in houses and its relation to the presence and severity of asthma in a population of Sydney schoolchildren. *J Allergy Clin Immunol* 1995;96:441-8.
25. Sakaguchi M, Inouye S, Yasueda H, Irie T, Yoshizawa S, Shida T. Measurement of allergens associated with dust mite allergy. II. Concentrations of airborne mite allergens (*Der I* and *Der II*) in the house. *Int Arch Allergy Appl Immunol* 1989;90:190-3.
26. van Strien R, Verhoeff A, Brunekreef B, van Wijnen J. Mite antigen in house dust: relationship with different housing characteristics in the Netherlands. *Clin Exp Allergy* 1994;24:843-52.
27. Chan-Yeung M, Manfreda J, Dimich-Ward H, et al. Mite and cat allergen levels in homes and severity of asthma. *Am J Respir Care Med* 1995;152:1805-11.
28. Luczynska C, Arrunda L, Platts-Mills T, Miller J, Lopez M, Chapman M. A two site monoclonal antibody ELISA for

- the quantification of the major *Dermatophagoides* spp. allergens, *Der p* 1 and *Der f* 1. *J Immunol Methods* 1989;118:227-35.
29. Ylönen J, Virtanen T, Rytönen M, Mäntytjärvi R. Quantification of a major bovine allergen by a two-site immunometric assay based on monoclonal antibodies. *Allergy* 1994; 49:707-12.
30. van der Hoeven W, de Boer R, Bruin J. The colonisation of new houses by house dust mites (Acari: Pyroglyphidae). *Exp Appl Acarol* 1992;16:75-84.

This document is a scanned copy of a printed document. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material.